

# BREACHING THE STRONGROOM

## *A Pervasive Informatics Approach to Working with Medieval Manuscripts*

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Abstract: This paper outlines a pervasive approach to informatics-enhanced humanities research on medieval manuscripts. Digital surrogates (created for conservational as much as for research purposes) provide a first step towards 'breaching the strongroom'. Yet even when libraries can offer scholars digital copies of manuscripts, the holdings available rarely match up *as a corpus* to those sought by a particular scholar. Progress towards overcoming the mismatch has begun to be made via large-scale online digitisation initiatives such as the *Roman de la Rose*, *e-Codices* and *Europeana Regia* projects, collating thousands of items from research libraries on different continents. Focusing on the *Online Froissart* project, the paper looks first at some new tools for making online manuscript collections more genuinely pervasive, insofar as they allow users to move seamlessly through, across and within them. The second topic addressed is the additional informatic uses to which the project's electronic images are being put (using as a springboard the analysis of their semantic content) in the wider context of e-Research conducted by an international consortium working out of the Universities of Sheffield, Urbana-Champaign, Michigan State and South Carolina and using the same Cloud-based technologies to investigate distinct but ultimately comparable image corpora.

## 1 INTRODUCTION

In 2011 an early 15<sup>th</sup>-century manuscript of Froissart's *Chronicles* was auctioned in Paris for 450,000 €. Known to specialists as the Clumber Park manuscript, it had originally been owned by the Duke of Newcastle and housed until 1938 in his library at Clumber Park, Nottinghamshire, UK. It is one of several Froissart manuscripts forming a part of the estates of wealthy patrons which seldom cross the researcher's path. In this instance the authors were alerted to the impending sale; one of the Online Froissart team left post-haste for Paris and by kind permission of the auctioneers saw the manuscript at the salerooms, taking a photographic record of it before it went to its (anonymous) new owner.

By far the majority of Froissart manuscripts, in contrast, are housed in major research libraries in Paris, London and Brussels. Others again are housed in Chicago, New York, The Hague, Toulouse, Rouen, Glasgow, Darmstadt, Berlin and the Vatican. Doing research on material of this kind is exciting but sometimes unusually challenging. Some libraries limit direct access to originals, for understandable reasons: they represent a significant part of any

library's cultural patrimony; their pigments and gilding can be damaged by abrasion or careless handling, and prolonged exposure to daylight can cause yet more damage. A careful record will normally be kept by the library of the dates and number of hours' exposure to light sustained by each manuscript during public exhibitions or examination by scholars. In some instances manuscripts are deemed too fragile or light-susceptible to be released at all, so researchers have to make do with 35mm black-and-white or colour microfilm, never an entirely satisfactory compromise.

## 2 LIBRARIES AND THEIR MANUSCRIPTS

National libraries sometimes (not always) have their own photographic studios and digital photography specialists. Schedules are governed only partly by scholarly interest in particular manuscripts; conservation requirements determine most decisions as to what is considered a high priority object for digitisation, exceptions tending to occur only where

money is not a problem, as when a scholar secures a generous research grant that includes some money to fund the digitisation of a particular volume or group of manuscripts. Research Councils are reluctant to disburse funds for digitisation alone, but may sanction an element of such activity if it can be shown to help address a precise research question. Digitisation projects on the grand scale happen only when researchers and libraries enter into mutually beneficial partnerships with wealthy philanthropic foundations such as the Mellon Foundation (who approach the scholar first). The JISC (UK) and European Framework 7 programme (EU) support medium-scale digitisation projects, whilst requiring them, entirely properly, to be underpinned by specific research goals and imperatives.

Smaller research libraries may boast rich manuscript collections but have only limited staffing resources and insufficient infrastructure or security to support digitisation. It can cost up to 10,000 € to hire an appropriately skilled freelance photographer for a 10-day shoot at home or abroad. Insurance and copyright issues have to be addressed, as do requirements already alluded to such as permitted light levels, the timespan available for the manuscript to be exposed to light in any given year or month, and mutually agreed image capture standards. Nothing will happen, though, unless the library is convinced that the photographer knows how to handle fragile material, and unless the manuscript has been cleared for photography. When everything comes together the result is an invaluable research tool that coincidentally prolongs the shelf life of the original artefact. And the library gets to retain a first-class digital copy for other researchers to use as first port of call (though nothing replaces contact with the original).

Some libraries charge per image; others charge nothing (for bona fide research use). Some charge proportionately for the right to publish a single image or whole manuscript; others may invoice a scholar for around £56K; it took several years for the authors successfully to persuade a national library to waive such a sum on the grounds that the images were needed for research rather than for conversion into a set of picture postcards. Post-shoot, it may take a further 1-2 years for a formal letter of authorisation to arrive releasing the images into the public domain; publication before the agreed date will rightly land the scholar in court. Even when everything has been cleared, researcher and photographer still need to ensure that copyright straplins are exactly right. If one is publishing on the web, additional, stringent requirements apply.

### 3 DIGITISING FOR PERVASIVE EXHIBITIONS

Digitisation of ancient manuscripts serves more than the needs of scholar or conservator. It provides, in addition, the basis for a range of pervasive approaches to library, museum or gallery displays. In December 2007 the Royal Armouries (UK) mounted an exhibition at their Yorkshire galleries in partnership with Sheffield University's French Department and Tribal plc. Featuring arms, armour and military tactics of the Hundred Years' War (*ca.* 1370-1420), its narrative content was supplied by Froissart's *Chronicles*, a prime witness to the conflict. The centrepiece was an early 15<sup>th</sup>-century manuscript of the *Chronicles* lent by Stonyhurst College, Lancashire. Its necessarily fixed display in a sealed glazed case equipped with humidity and temperature monitoring systems was complemented by Kiosque, a system developed jointly by Tribal and Sheffield University to provide enhanced access to the visual and semantic content of the manuscript (of which only a recto-verso display could be seen in the showcase). RFID-powered panels designed by a team led by Chris Rust from Sheffield Hallam University's Centre for Creative Design responded to the several interests of visitors of all ages and backgrounds. The RFID-based and Kiosque-driven displays each provided access to multiple layers of semantic content, complemented by evocative soundscapes using 14<sup>th</sup> century music.

#### 3.1 Pathways Through the Data

An important component of the Kiosque touchscreen displays and virtual gallery tours was their provision of pathways through the digital surrogate of Stonyhurst College Library, ms. 1, with its glorious miniatures and secondary decoration, and through a good half dozen sister manuscripts also, represented at the exhibition by their digital surrogates. Users could in this way compare and contrast varying visual treatments of the 'same' scene or episode as it occurred in this or that manuscript. The visual and narrative content of a handful of manuscript books was in this way brought 'out of the strongroom' and into the light of day, or in this case the more public arena of the museum, with no damage to the originals.

Spring 2010 saw the transfer of the Royal Armouries exhibition to the Hôtel des Invalides in Paris, home to the Musée national de l'Armée. Once again, real and virtual manuscripts provided the climax to an exhibition which (as at Leeds)

featured the skills and products of the medieval armourer, and of the manuscript painter and copyist. This time the real manuscripts on show were two sets of 'twins', each comprising two volumes and normally housed, respectively, at the Public Library in Besançon, and the Bibliothèque nationale de France in Paris. The virtual surrogates of the four volumes were shown as part of a wider Froissart Manuscripts corpus comprising 6,000 high-resolution images captured from ten digitised volumes (2TB of data) including Stonyhurst College Library, ms. 1.

### 3.2 Questions of Provenance: The Corpus

The original manuscripts were all produced during the first quarter of the fifteenth century, many under the supervision of Pierre de Liffol, a bookseller who, like some kind of medieval entrepreneur, glimpsed a niche opportunity for the production and sale of luxury copies of Froissart's *Chronicles* to rich patrons from the aristocracy. The story behind their production and decoration provided part of the backdrop to the Paris and Leeds exhibitions, the Kiosque software helping to tell the tale to their modern audiences.

### 3.3 Virtual Vellum: A Pervasive Viewer

Slideshows from the two exhibitions can be viewed via the *Online Froissart*, a new electronic edition of the *Chronicles* funded by the Arts and Humanities Research Council. A prime component of the *Online Froissart* interface is an external viewer called Virtual Vellum; it allows users of the site not only to open up images of any given folio (displaying text, miniature or both), but to place these next to images selected from other virtual manuscripts for comparison. This ostensibly simple feature is missing from many otherwise first-rate electronic manuscript sites such as those referred to in our abstract. Reprising the 'two slide projectors and matching adjacent screens' arrangement so beloved of art historians, Virtual Vellum (Figure 1) provides a flexible interface through which to compare, contrast and measure juxtaposed images from different manuscript 'books' whose originals were copied and illustrated in the same workshops, but today find themselves dispersed to research libraries across Europe and the USA.



Figure 1: Virtual Vellum showing related images from 4 different manuscripts painted by the Giac Master.

### 3.4 Four Books, Two Artists

The visual and semantic content of the four virtual volumes displayed at the Invalides in 2010 is rich and multi-layered. Art historians working on early 15<sup>th</sup>-century iconography and artistic schools in Paris long ago identified the artistic hand responsible for the primary decoration of Besançon Public Library, ms. 864, and Paris, Bibliothèque nationale de France, fonds français ms. 2664, as being that of a disciple of a known artist called the Rohan Master. The artist responsible for the miniatures of Besançon Public Library, ms. 865 and for most of those in Paris, Bibliothèque nationale de France, fonds français ms. 2663, on the other hand, was for many years thought to be 'a mediocre follower' of the Master of the Berry Apocalypse, the latter so-called after a copy of the Book of Revelation illustrated for the Duke of Berry, housed today at New York's Pierpont Morgan Library as ms. M.133. Recent scholarship by Inès Villela-Petit argues that this artist deserves to be more clearly distinguished from the Master of the Berry Apocalypse and should henceforward be known as the Boethius Master (having illustrated a fine copy of Boethius's *Consolations of Philosophy*). As for the illustrations to Besançon Public Library, ms. 864, these ought more properly to be attributed to a *forerunner* (rather than a *disciple*) of the Rohan Master; this newly-identified artist is henceforward to be known as the Giac Master on account of his having illustrated a book of Hours for Jeanne du Peschin, dame de Giac.

## 4 THE ONLINE FROISSART

The Paris exhibition closed in July 2010, but a lasting record is preserved in a special number of *Art*



*de l'Enluminure* (which served as catalogue to the exhibition). Offering readers a comprehensive account of the background to and semantic content of the Paris exhibition, it can be explored alongside the essays and transcriptions provided by the *Online Froissart*. The *Online Froissart* also includes a large body of complete and sample transcriptions of Froissart manuscripts rendered on screen via TEI-conformant XML and accompanied by a powerful search engine and collation tool allowing users, respectively, to locate elaborate textual strings and to compare different versions of the 'same' text, in ways that pinpoint their variant forms.

#### 4.1 Words and Their Uses

In addition to these tools, a viewing mode in which every word becomes clickable sends users, via a sophisticated lemmatising tool, from a selected word to its equivalent entry in the online *Dictionnaire du Moyen Français* (ATILF Laboratory, Université de Nancy 2). The *Online Froissart* has, in turn, donated its holdings of many millions of words and texts in Middle French to the *DMF*, completing the circle. This intrinsically pervasive activity has enriched the work of each participant in an Anglo-French initiative funded by the UK's Arts and Humanities Research Council and British Academy, and by the Centre National de la Recherche Scientifique. Further enrichment has come via this same project through input from key partners at Edinburgh and St Andrews Universities (*Christine de Pizan Queen's Manuscript* and *Clermont-Ferrand Archives* projects).

The consortium described affords a prime example of several projects joining forces and breaking through disciplinary and national barriers to generate a product infinitely richer than the sum of the component parts. Interfaces are extended and adapted to new uses, and different kinds of complementary expertise brought to bear on intractable but mutually interesting research questions.

#### 4.2 From Semantics to Informatics

The projects just described have focused primarily on semantic and visual content as traditionally understood by researchers in the humanities. We turn now to a more pervasively forensic approach to the data constituted by our virtual manuscript corpus, bringing to the table the additional skills of practitioners of informatics and e-Research.

## 5 DIGGING INTO DATA

In 2009 the JISC (UK), National Science Foundation (USA) and National Endowment for the Humanities (USA) issued a funding call under the "Digging into Data Challenge" banner. Eight projects were funded including one involving input from the Froissart Manuscripts corpus. Common cause was found by researchers working with digital images of medieval manuscripts, 17<sup>th</sup>- and 18<sup>th</sup>-century British and French maps of the Great Lakes, and large-scale collections of 19<sup>th</sup>- and 20<sup>th</sup>-century quilts. The scientific platform for the consortium, bringing together researchers from Sheffield University's Department of French and Humanities Research Institute, the National Center for Supercomputing Applications at Urbana-Champaign, the College of Fine and Applied Arts at the University of Illinois, also Urbana-Champaign, Michigan State University, the University of South Carolina and several key library and museum partners, is described elsewhere (article for *First Monday*; see References). All of the collections benefited mutually from the research conducted; each team contributed to that research and to the project's virtual infrastructure. Algorithms developed for one collection were subsequently applied to the other two, in another manifestation of pervasive informatics for the Humanities. Our project was baptised "Digging into Data to Answer Authorship-Related Questions" or DID-ARQ for short. The following paragraphs home in on work done on the Froissart Manuscripts corpus, just one exemplification of the pervasive approach adopted by a consortium working in the Cloud.

### 5.1 The Four Manuscripts Revisited

The starting point for the DID-ARQ humanists was the four Froissart volumes from Besançon and Paris, whose miniatures, initial letters and decorative borders had been entrusted back in 1410-1418 to the workshops of the Giac and Boethius Masters. These artists, as seen earlier, were favoured by bookseller Pierre de Liffol: their handiwork can be explored in these and other virtual manuscripts forming a corpus viewable via the *Online Froissart* website. Their artistry, and the penmanship of the scribes given the job of copying the texts, are an eloquent testimony to the remarkable achievements of book trade artisans in Paris during the first quarter of the fifteenth century.

The DID-ARQ project considered the virtual manuscripts no longer solely as flexible surrogates for originals locked in closed display cases for an exhibition, or hidden away in their several research

libraries, but as a data source in its own right. Relationships carefully fostered with conservators and librarians, plus the skills of a talented specialist photographer, had led to the capture – under almost identical conditions – of ten complete facsimiles. As we have seen, development of fit-for-purpose viewing software followed in the guise of Virtual Vellum; finally, copyright clearance was secured for shared use across the DID-ARQ consortium of all but two of the virtual manuscripts and their images (the final two were cleared for use in June 2011).

## 5.2 Artistic Hands and Informatics

Colleagues at Illinois's College of Fine and Applied Arts, in partnership with NCSA, adopted as their particular objective the exploration and interrogation of the virtual manuscripts' decorative and illustrative content, concentrating on the four volumes displayed in Paris. The Boethius Master's approach to battle scenes in Besançon 865 is characterised by 'rows of serried ranks of helmets emphasising the massing effect of these groups of undifferentiated warriors' (I. Villela-Petit, *The Artists: The Giac Master and the Boethius Master, illuminators of the war*, essay published on the *Online Froissart*). Armour is invariably blue, conveying the bluish quality of steel, whilst the colour of the surcoats introduces some chromatic variety: orange, green and sometimes dark pink or mosaic gold. The inexpressive faces of the artist's courtiers have a pallid complexion shaded with blue, characteristic of this Master.

Features typical of the Giac Master as shown in Besançon 864 include 'the moon faces of his characters with their modelled pinkish-brown complexions and elongated bodies. Where a group of soldiery is depicted, a pale blue tint used for the front row merges into a darker ultramarine towards the rear, suggesting real metal' (eadem).

Image samples were selected on grounds of their pertinence to art historians intent on identifying and discriminating between discrete artistic hands; they included faces, crowns and helmets (Figure 2). To these more traditional research questions were added a 'layer' provided by e-Researchers looking at the same data from their standpoint. This led to a fusion of art historians' and informaticians' methodologies, generating hybrid research questions:

- How does the application of computer algorithms to analysis of portrayal of the human face or of items of armour in the miniatures help scholars to refine the parameters of discriminating features traditionally used by art connoisseurs for

characterising the hands of the Giac and Boethius Masters?

- What do these algorithms and their application reveal about the hands responsible for secondary decoration (illuminated initial letters or marginal decoration) in the same manuscripts?

- To what extent might these new techniques assist scholars to refine current knowledge of the human presence behind such broad-brush labels as 'Giac Master' or 'Boethius Master'? Do our preliminary results suggest the presence and activity of more than one individual active under each of these convenient but vague designations?

Using the virtual manuscripts corpus, specialists in art history at Illinois supported by informaticians took as their objective two iconographic elements widely used by art historians as an index of authorship. They started with two complementary quests: (i) for consistency of colours used for depicting the faces of queens, kings, and other figures within the illuminations, and (ii) for discriminating colour space representations to characterise and separate out two or more artistic hands. To the faces were applied algorithms used for measuring different or differential colour spaces: RGB (CMY), HSV, YIQ, YUV, XYZ, LAB and LUV. Original RGB images from the database were subjected to colour space conversion, producing an HSV image. Segmentation algorithms generated a Mask Image. Each of these two outcomes was then subjected to statistical analysis ( $\mu H$ ,  $\mu S$ ,  $\mu V$ ). A strong indication of the unique colour palette characteristic of each artistic hand duly emerged. Our most recent work has focused on quantifying the colour space distortions due to image manipulations (by looking at how screen captures of the originals were taken, at the impact of changing file formats and of the introduction of file formats with lossy compression, as well as the passing of images into PowerPoint slides).



Figure 2: Faces and Armour, Boethius Master (to the left) and Giac Master (to the right).

### 5.3 Scribal Hands and Informatics

The Sheffield operation concentrated on the copying process and its outcome, i.e. the handwriting or *scripta* constituting the copied text. Pierre de Liffol produced his books primarily for clients in the service of Charles VI of France, though the iconographical emphasis of at least one book testifies to a client with pro-English sympathies. In every case, though, the texts were copied from exemplars whose contents were unlikely to offend either camp. The work of copying the text of the *Chronicles* was typically carried out by two teams of three scribes to whose workshops the unbound quires were sent by Pierre de Liffol (before being sent on in turn to the Giac and Boethius Masters for illustration and decoration). Scholars call the scribes ‘F’, ‘B’ and ‘D’, so anonymous are they. Palaeographers have traditionally built up an idea of scribal ‘personalities’ by singling out and describing the distinguishing features of particular hands. Scholars have in this way adduced significant characteristics on which to found their conclusions: particular ways of executing certain sequences of letters (e.g. the consonant clusters ‘th’, ‘ch’, or the group ‘-ent’) or certain recurring, distinctive ways of writing an ‘a’ or ‘r’ (against models furnished by contemporary bookhands as taught to all apprentice scribes). The DID-ARQ archive comprises, as noted above, ten virtual manuscripts, each containing ~300,000 words and all copied in varieties of a bookhand known as *littera cursiva libraria*.

In due course, DID-ARQ began to test some of the hypotheses adduced by palaeographers (using more traditional modes of scholarship) against the virtual dataset, applying algorithms described below. The key research question (broadly formulated) underpinning the team’s research was:

- How might one adduce pertinent e-Science methodologies for the interrogation of such a large-scale database, the better to explore, characterise and circumscribe particular manifestations (individual scribal hands ‘F’, ‘B’ or ‘D’...) of an attested early 15<sup>th</sup>-century bookhand, *littera cursiva libraria*?

Traditional scholarship by palaeographers over several generations suggested that it would be fruitful to compare letter and word clusters across several hundreds of digitised folios of writing as realised by a particular scribe such as Hand F, for instance, using semi-automated definition of the perimeters of letter and word shapes; this, it was postulated, should bring new scientific light to bear upon the hypotheses of traditional palaeographers. It should, in particular, generate augmented – and arguably more objective – evidence towards

assignment to a particular scribe of responsibility for given sections of a given manuscript, ‘X’. Palaeography is acknowledged to be, in some respects, an intuitive ‘science’ based on eye-brain coordination, dependent to at least some extent on the individual skills, experience and perceptive acuity of individual practitioners. The application to the sample corpus of our e-Science algorithms, it was thought, might generate more objectively quantifiable results.

Once Hand F’s written ‘idiolect’ had been more precisely defined in the manner described, it ought to become possible to search for and identify his or her activity across other manuscripts such as ‘Y’ or ‘Z’. Palaeographers had already adduced some professional evidence to suggest that this kind of migration was happening across the volumes of the Pierre de Liffol corpus; it was our expectation that more accurate methodologies applied to the virtual manuscripts might confirm these relatively more intuitive hypotheses, and account for them on the basis of more overtly scientific evidence. Potentially rich areas for electronic investigation included the *ductus* (the kinetic movement and direction of the hand and pen as they make their marks, their upward and downward strokes and curves) as realised by a particular scribe, the overall neatness of the particular folio, the (characteristic) recourse by a scribe to abbreviations, and their deployment of particular spelling patterns.

### 5.4 Maps, Quilts and Manuscripts

Work done by other members of the DID-ARQ team (at Illinois and Michigan) on the French and English maps and quilt collections yielded other potential ways of querying the virtual manuscripts’ artists hands (Figure 3).

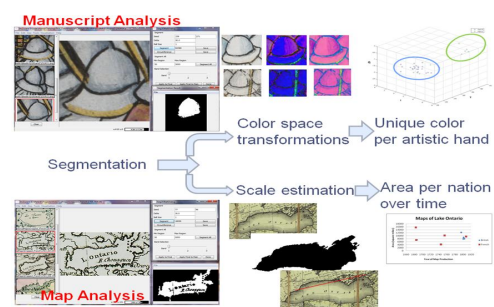


Figure 3: Analysing Manuscripts and Maps.

Looking next at the scribal hands, DID-ARQ project members extracted a ‘digital fingerprint’ for each of the medieval copyists, using Polygonal Models and Shape Recognition algorithms. Sobel Edge detection



(using the Image2Learn API) was applied to source images accessed from commonly-shared samples mounted on the project's Medici image library. Line segments were then fitted to edge map data using the expectation-maximisation (EM) algorithm. Shape Recognition algorithms were applied to polygonal models to identify letters, words, symbols and patterns in the manuscripts' texts (Figure 4). First results proved encouraging. At time of writing, preparations are in hand for further work involving the running of the same algorithms on NCSA's Petascale HPC machine *Blue Waters*, or on the NSF Teragrid's HPC resources. The computation takes many hours of computing time. Preliminary results appear to promise that over coming months the potential for identifying a steadily more objective digital fingerprint for some of our hitherto shadowy medieval copyists, Hands F, C and D, may evolve into a firmer reality.



Figure 4: Identifying Letters and Words.

## 6 CONCLUSIONS

Humanities scholars are increasingly engaged with the world of computing, whilst scientists working in e-Science and Pervasive Informatics are becoming equally fascinated by the fresh opportunities opening up for work that may generate purposive new bonds between what C.P. Snow labelled in his celebrated 1959 Reid Lecture the 'Two Cultures' (Arts and the Sciences).

Digitisation projects are important to research libraries and conservators, and to scholars to whom direct access cannot always be given to original manuscripts. They have a bearing also on the development of genuinely pervasive 'union' interfaces deployable via electronic editions, capable, like Virtual Vellum and the *Online Froissart*, of bringing together for comparison materials housed in discrete research libraries (many of which unfortunately still insist, when federating their virtual holdings, on retaining their own local browsers – thereby limiting the pervasiveness of the aggregated and shared material). Digitisation brings huge benefits to museum and gallery visitors, where

specially designed software such as Kiosque allows users to explore surrogates of books sealed in fixed position within a glazed case, or to create customised pathways through displayed material.

Image data can also be mined using techniques developed by imaging and computing specialists; exciting results are being generated in the process. This paper has sought to demonstrate in particular how, in the domain of manuscript studies, the more traditional methodologies of art connoisseurship and palaeography can benefit from the application to their objects of study of Sobel Edge and Polygonal Shape Fitting algorithms (derived in turn from research on manuscripts, maps and quilts).

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After close on two years of endeavour the DID-ARQ team feels entitled to lay its own modest claim to Aristotle's dictum in the *Metaphysica* about the whole becoming 'more than the sum of its parts'. The DID-ARQ project description and the visual materials pertinent to each dataset can be found on the three project websites:

NCSA/UIUC:

<http://isda.ncsa.uiuc.edu/DID/index.html>

MSU:

<http://projects.matrix.msu.edu/did>

University of Sheffield:

<http://www.hridigital.co.uk/did>

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Virtual Vellum: <http://www.shef.ac.uk/hri/projects/projectpages/virtualvellum.html>

Image Spatial Data Analysis Group: <http://isda.ncsa.uiuc.edu/>

Image2Learn: <http://isda.ncsa.uiuc.edu/Im2Learn>

Institute for Computing in Humanities, Arts, and Social Science: <http://ichass.illinois.edu>

National Center for Supercomputing Applications: <http://ncsa.illinois.edu>

University of Illinois Libraries: <http://www.library.illinois.edu>

MATRIX: <http://www.matrix.msu.edu>

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